Super-Resolution Vision System (SRVS)

Proposer's Day Brief
Washington, DC
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NOTES:
(1) TECHNOLOGY DEVELOPMENT AND TESTING APPROACHES ARE PRESENTED INFORMATION ONLY AND SHOULD NOT BE REGARDED AS REQUIREMENTS FOR PROPOSAL UNLESS STATED IN THE PROPOSER INFORMATION PAMPHLET.

Program Overview

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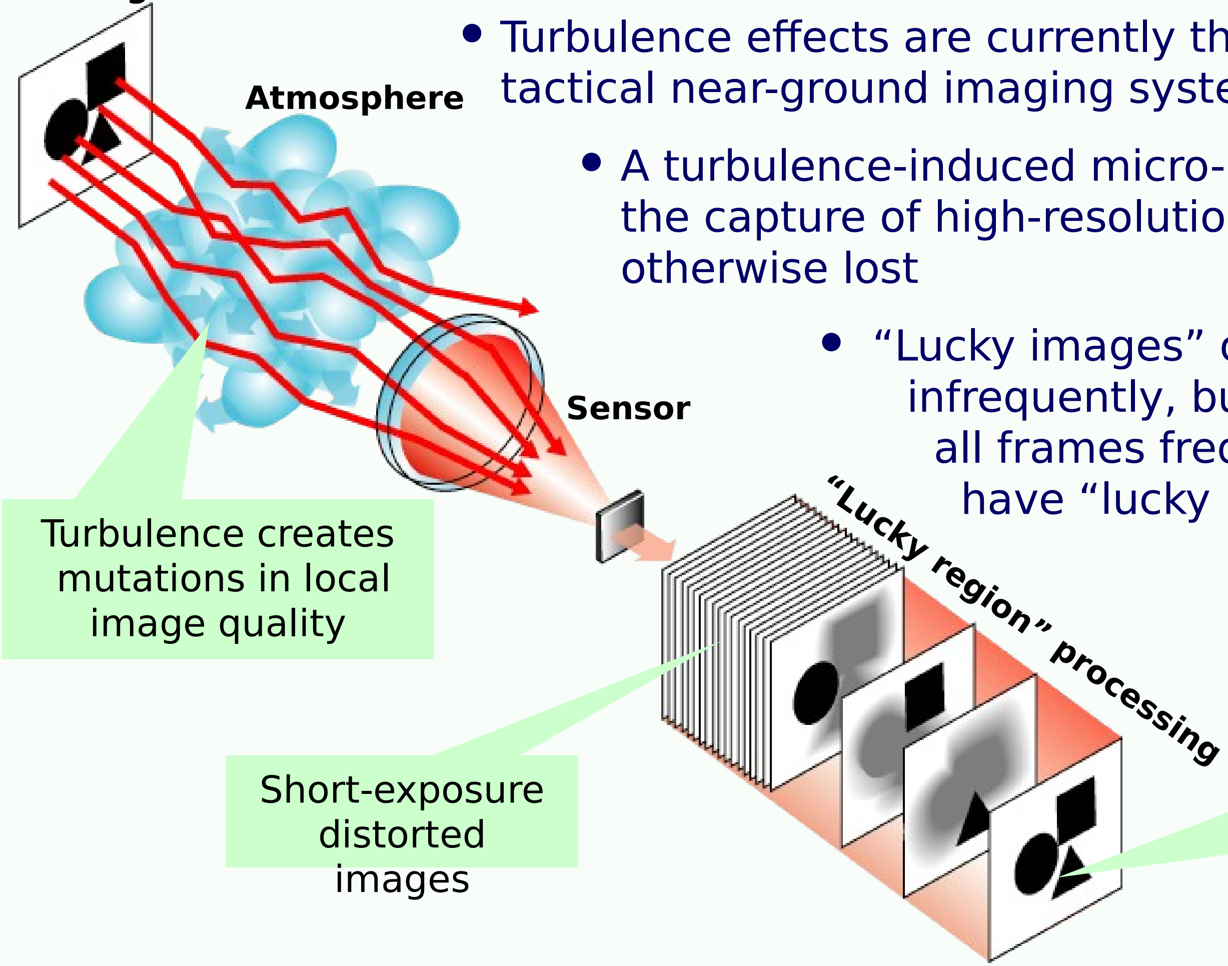
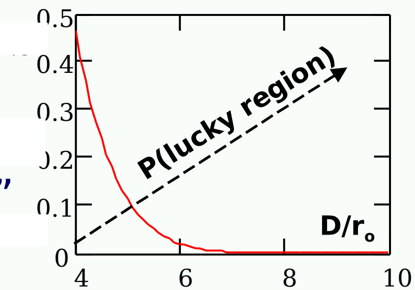
SRVS: Physical Concept

- Turbulence effects are currently the determining factor in tactical near-ground imaging system resolution
  - A turbulence-induced micro-lensing phenomenon enables the capture of high-resolution image information that is otherwise lost
    - "Lucky images" occur infrequently, but all frames frequently have "lucky regions"



Probability of "lucky" image



"Probability of getting a lucky short- exposure image through turbulence" (FRIED, 1978)

Turbulence-induced random phase distortions can be exploited to achieve resolution beyond the diffraction limit

Potential for System Performance

Long-Term Average

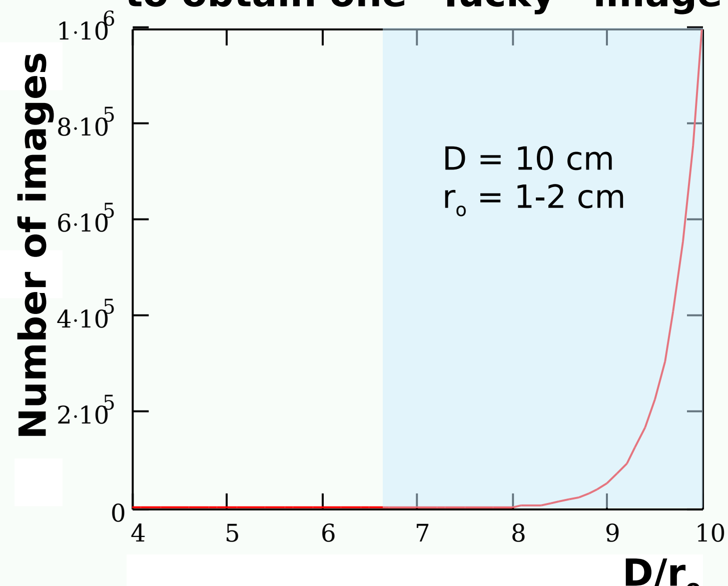
Super-Resolution Image

Long-term average of 100 short-exposure image frames, with super-resolution image constructed from lucky regions in these 100 image frames [experimental laboratory data obtained using a single phase screen, M. Vorontsov, unpublished data, 1998].

"Lucky" image– image with wave-front distortion over the aperture < 1 rad² (near-diffraction limited)

"Lucky" region – image region with near or better-than-diffraction limited resolution

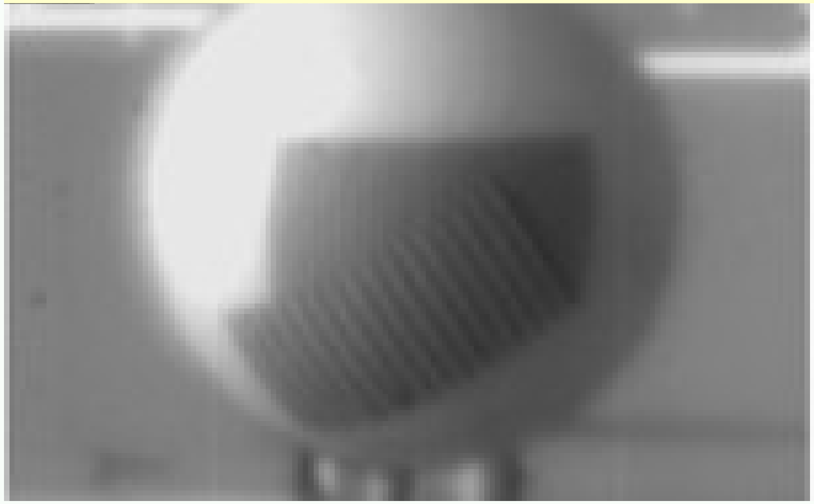
Number of images required to obtain one "lucky" image



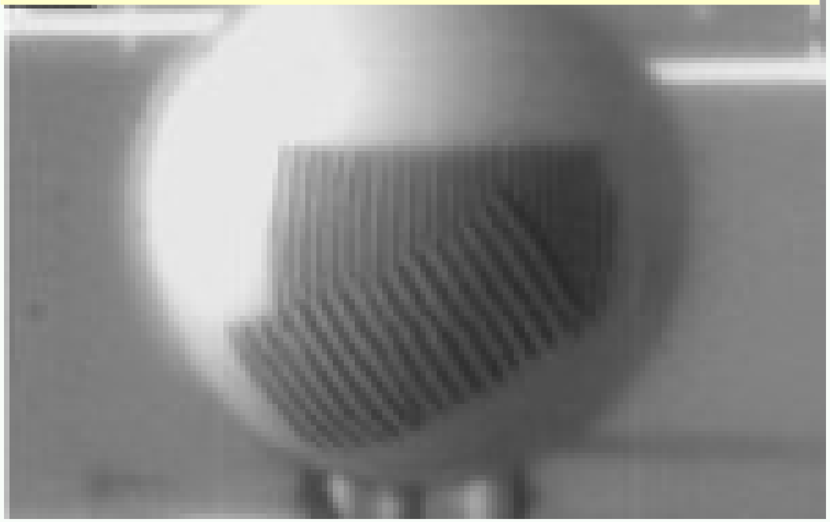
"Probability of getting a lucky short- exposure image through turbulence" (FRIED, 1978)

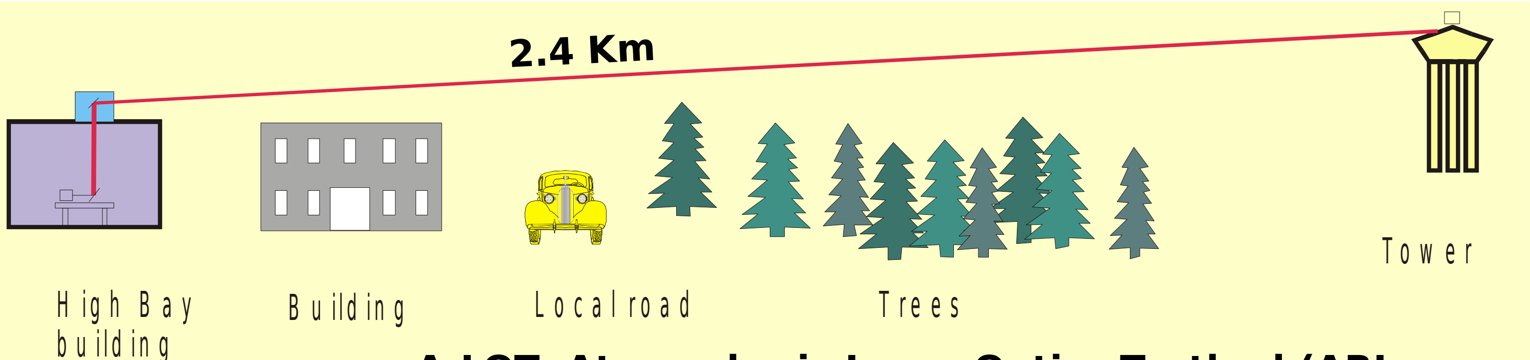
Experimental Proof of Principle

Long-term average



Super-Resolution image





A-LOT: Atmospheric Laser Optics Testbed (ARL, Adelphi, MD)

Program Objective

Develop an optical spotter scope with range performance better than current systems

Key Technical Innovation

- Exploit turbulence-generated micro-lensing phenomenon

Key Technical Application

- Facial recognition and reading text at extended ranges

The mission

- Recon/sniper - Team mission
  - Two optical sights
  - Spotter scope – target detection and recognition
  - Rifle scope – aim point
- Work as team

Program Goals

- Develop Technologies for and Build
  - field prototype man-portable optical system
    - credibly demonstrate improved recognition range over existing systems
    - Less than 2 kilograms
    - Less than 35 cm length
    - 6 cm aperture

Program Technical Interests

- Development of image quality computational algorithms for:
  - on-the-fly local image quality analysis and fusion (image quality map estimation and fusion of “lucky” high-resolution image regions)
  - rapid, on-the-fly local region shift/jitter removal and image stabilization
- Design of interface between high-speed camera and computational hardware
- Investigation and resolution of critical technological issues associated with the physics of super-resolution
- Field demonstration of a prototype scaled to in-service system size, weight and power (use of standard batteries)

Program approach

- Technologies first developed and proven in laboratory and brassboard environments
- After demonstrations show the technology viable and technically sound
  - prototype an advanced development model, scaled to field experiment size, weight and power

The End State

- Man-portable spotting scope system
- Comparable in size and weight to existing systems
  - weight less than 2 kilograms, including the weight of any batteries (standard AA preferred) and electronics
  - length less than 35 cm
  - 6 cm optical aperture
- System should be able to capture at least one hundred 1 megabyte sized images and be able to export them in a common format onto a common media

Technical Challenges

- Algorithms for on-the-fly (<5 msec) local image quality analysis and fusion in volume turbulence (image quality map estimation & “lucky” region fusion)
- Rapid, on-the-fly local region shift/jitter removal combined with on-the-fly lucky region fusion for volume turbulence (new algorithms required)
- Image stabilization and pointing, acquisition and tracking of targets in a compact, man-portable package
- Photon starving under low-light conditions
- High performance, low-power image processing

Integration challenges

- Image stabilization and pointing, acquisition and tracking of targets in a compact, man-portable package
- System size, weight and power
- Power management (use of standard batteries)
  - environmental Packaging

Programmatics

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Schedule

Phase I

BAA Release **March 3, 2006**

Proposers' Conference **March 9, 2006**

Proposals Due **April 17, 2006**

Source Selection Completed **May 2006**

Contract(s) Awarded **July 2006**

Go/No Go Phase 1

For severe volume turbulence ($C_n^2 \sim 5\times10^{-13}$ $m^{-2/3}$) and full scale facial images meeting ANSI INCITS 385-2004, demonstrate with an aperture not to exceed 6 cm better-than-diffraction-limited super-resolution imaging, with resolution greater than one-half cycle per millimeter, at a speed of not less than 1 Hz and a range of at least 1 kilometer.

Go/No Go Phase 2

- For severe volume turbulence ($C_n^2 \sim 5\times10^{-13}$ $m^{-2/3}$):
  - With an aperture not to exceed 6 cm, demonstrate that full scale facial images meeting ANSI INCITS 385-2004 can be correctly identified by trained observers (90% correct identification) at a distance of 1 km (representing a 3x improvement over current performance).
  - Demonstrate better-than-diffraction-limited super-resolution imaging at a speed of not less than 1 Hz where human subjects moving at 1 m/s can be correctly identified by trained observers (90% correct identification) at a distance of 1 km.

Go/No Go Phase 3

Develop prototype super-resolution spotting scope replacement for a Leupold® Mark 4® (part number 53756 or 60040, or equivalent) 6 cm aperture spotting scope with specifications that do not exceed the following in size and weight: 35cm length, 2 kg weight. Prototype system must operate with commercially available batteries (AA preferred), with an operational life sufficient for capture of 100 1MB super-resolution images, and must meet or exceed Phase 2 imaging and identification performance at a distance of at least 1 km in severe turbulence ($Cn2 \sim 5x10^{-13}$ $m^{-2/3}$).

Programmatics

- Phased program
  - Phase 1 is the base program; subsequent phases are options
  - Each phase will have metrics to determine potential for continuation to the next phase
  - Likely to have only one team go forward to Phase 2
- Teaming
  - Strongly encouraged: combine expertise to provide good value to Government and cross-pollination of ideas
- Use or participation of Government labs
  - Nature of partnering arrangement must be described
  - Government labs cannot be exclusive; firewalls needed